civil defense Technical Bulletin

A DIGEST OF TECHNICAL INFORMATION

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PERSONAL DOSIMETERS FOR RADIOLOGICAL DEFENSE

A dosimeter is a device worn by a person for measuring and registering his total accumulated ionizing radiation exposure. Personal dosimeters are designed to measure exposures which may result during and after an atomic explosion in the 50 to 600 roentgen range. They should not be confused with the lower range, more accurate organizational dosimeters worn by civil defense workers in contaminated areas. (Organizational dosimeters were described in FCDA Advisory Bulletin No. 89, Jan. 15, 1952.)

A dosimeter may either be read directly through color changes or meter indications, or may require supplementary processing and/or reading equipment. The exposure indicated by a dosimeter should provide an index to the biological damage produced in a person by that same type and amount of radiation. The basic unit for gamma radiation, the roentgen (r) (which is defined in terms of the effect of radiation on air) is applicable over a wide range of energies (wave lengths). Within most of this range there is a nearly constant relationship between the energy absorbed per gram of air and the energy absorbed per gram of tissue. Most of the materials used in dosimetry respond to the higher energy (more penetrating) radiation in a way which parallels tissue or air. For the lower energies, however, many tend to read high and therefore are said to be energy dependent. Photographic film, for example, may indicate 30 times true value, and an indication of 10 times true value is not uncommon. Energy dependency can be greatly reduced by enclosing a dosimeter in a shield selected on the basis of the particular energy dependency characteristic of the material employed.

Dosimeters that change color as a result of irradiation may be read by means of calibrated color charts. Usually the charts show several steps of progressively different colors or shades of color and the dosimeter is matched to one of the chart steps. Each step represents a specific number of roentgens and the markings may be stamped adjacent to the steps or may appear on a separate reading key. The wider the step, the greater is the uncertainty of reading. Variations in response due to such factors as spectral and temperature dependency and differences in sensitivity have a disproportionate effect. If the exposure is near the center of an exposure range, these errors will have a minimum effect, being partially or completely masked by the inherent uncertainty of reading. If the exposure is near an extremity of a range, the errors will have a maximum effect and may result in the selection of the wrong step.

Personal dosimeters are not the only source of information about a person's exposure to radiation. Knowledge of the size of a bomb and its point of detonation, which can be determined by various methods, and of a person's location at the time of the burst permits a rough calculation of the amount of exposure. Calculations are particularly useful for determining areas in which occupants have not been exposed to amounts of radiation sufficient to cause concern. However, within exposed areas, the difficulty of ascertaining shielding effects of shelters, buildings, and terrain may limit the value of this method of dose determination.

Many types of personal dosimeters are now under development both by private industry and Government-supported laboratories. Some are nearing completion and dosimeters will soon be offered for public sale. Public Law 920 does not authorize FCDA to expend funds for personal equip-

ment. However, FCDA is issuing a series of bulletins to assist State and local civil defense officials in deciding whether personal dosimeters are necessary in their civil defense programs.

This bulletin, TB-11-2, discusses general factors to consider in making this decision. TB-11-3 discusses dosimeters generally and points out advantages and disadvantages of those most promising for civil defense use. TB-11-4 describes the availability of these dosimeters and results of tests on two of them. Additional bulletins will be issued as information on other dosimeters becomes available.

Civil defense officials should make a careful study of the following considerations before purchasing or recommending personal dosimeters:

(a) Evaluating Radiation Casualties

Personal dosimeters may be of assistance in diagnosing atomic bomb casualties. However, because of certain uncontrolled variables, a dosage reading must <u>not</u> form the sole basis for evaluating the degree of radiation injury. Two such variables are the wide differences of sensitivity to radiation among people and the possibility that through partial shielding the part of the body near the dosimeter may have received more or less radiation than other parts. Diagnosis, prognosis, and treatment must be based on the entire clinical picture.

(b) Psychological Effects

Dosimeters would have definite psychological value for persons not exposed to significant amounts of radiation. Assurance that he has not been dangerously exposed would permit a person to concentrate on his emergency duties. In event of exposure, however, the case is not so simple; some may react so that they become of little use, or even a definite liability, to civil defense activities. Some may take a devil-may-care attitude and, feeling doomed, overexert themselves or needlessly receive additional exposure. However, the majority will probably better adjust themselves to the knowledge that they have been exposed than to the uncertainty of not knowing.

(c) Civil Defense Workers

Civil defense workers may be required to perform duties involving radiation exposure. See "Emergency Exposures to Nuclear Radiation," FCDA TB-11-1, March 1952. If a worker had been carrying a personal dosimeter before and after an atomic blast, his total exposure will have been measured. This information would be of value in determining his assignments.

(d) Medical Information

If persons exposed to radiation during and after an atomic attack are equipped with personal dosimeters, correlations between degrees of exposure and resulting casualties may be established. The medical record of a personal dosimeter reading might be of assistance in future diagnostic and therapeutic considerations. The information would also be helpful in studying the long-term effects of exposure in genetics and in the production of disorders, such as cataracts, leukemia, and cancer.

(e) Operational Problems

(1) Coverage

The over-all advantage which may be realized from any dosimetry program will be in proportion to the number of peopl[e] who are wearing dosimeters a[t] the time of attack. Therefore, any civil defense organization which provides or recommends use of personal dosimeters must consider the problems of supply and of persuading people to wear dosimeters at all times.

(2) Obtaining dosage data

Specialized equipment must be obtained and maintained for those dosimeters requiring processing or reading. Following attack, this equipment and properly trained personnel must be available.

(3) Data records

To obtain the maximum benefit from a dosimetry program, an adequate system of records must be established. This is more difficult with dosimeters which do not themselves provide a permanent record. With dosimeters which must be separated from their wearers for proc-

essing or reading, a positive system for identifying dosimeters with wearers must be devised. This is particularly important when dosimeters are processed in large batches or at some distance from the point of collection.

(f) Summary

Personal dosimeters do not provide an exact index of the degree of radiation injury and must not form the sole basis for medical treatment; however, they may be of value in assisting in diagnosis, and in giving a person psychological assurance when he has not been dangerously exposed. They would be useful in indicating whether a person may perform emergency duties that involve additional exposure, in providing information for future diagnostic and therapeutic considerations, and in providing more exact scientific correlation between the degree of exposure and seriousness of the injury. For an effective dosimetry program, problems of supply and of persuading people to wear their dosimeters must be solved. An adequate system for obtaining and recording dosage information must also be established.

Recommendations

At present, FCDA is not recommending personal dosimeters for general use. Cost of dosimeters, materials and labor required to produce them and time and effort required by a civil defense staff to effectively organize and operate a dosimetry program would seem to outweigh the anticipated benefits.

In some cases State or local civil defense organizations may decide that the advantages outweigh the disadvantages and recommend the use of personal dosimeters. These organizations should carefully study the other technical bulletins in this series to determine which dosimeter types are best suited to their needs and their availability. Personal dosimeters are being included in the instrument evaluation program undertaken by the National Bureau of Standards for FCDA. Specific dosimeters should not be procured or recommended until they have been tested and the results made available in future FCDA technical bulletins.

The following general characteristics should be used as a guide in considering the choice of a personal·dosimeter:

(a) They should record the integrated gamma radiation in a form from which the dose can be quickly and accurately determined.

(b) They should measure within plus or minus 20 percent or within plus or minus 50 roentgens, whichever is smaller. This precision should not be affected by conditions of use or storage such as temperature, humidity, mechanical shock, fumes, and radiation rate. Neither should this precision be reduced in practical use as a result of a radiation wavelength (energy) dependency of the dosimeter.

(c) They should be lightweight and so made that they can be worn with a minimum of inconvenience.

(d) They and any auxiliary equipment needed for processing and/or reading should be simple and inexpensive and should require a minimum of critical materials in their production.

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